Menlo Park Notebook #137 [N-80-07-16]

This notebook covers the period July-December 1880. The entries are by Francis Upton and Francis Jehl. Some entries are probably by William Hammer. The book contains calculations and notes regarding insulation for underground cables and the electric railroad. The label on the front cover is marked "Lines Insulat" There are 284 numbered pages.

Blank pages not filmed: 88-91, 140-143, 146-149, 152-253, 262-267.

Missing page numbers: 111-114, 271-272.

Conducting wire to lines
12.3 ohms

to RR 9 ohms

In bridge German silver
box with string on it balanced
by Box No. 2 6300+1600+400
8 in 1/1000 other sides
of bridge
0

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BOARD OF PATENT CONTROL,

120 BROADWAY, NEW YORK.

From Library
GENERAL ELECTRIC.
44 Broad St. N.J.

May 1, 1896

Blank Book Manufacturers.
777 Broad St. Newark, N.J.

12.9
3 | 36.0
180

7 ohms

181 lbs
27 Ohms
324 Sq.

July 16 1880

		To ground	
wet days			
18 wire circuit	.55	25.	43.
Carmen Circuit	1.14 / 2800	4.2 / 2900	8.2 / 2100
6 wire circuit	61.8	25.6	50.5
Edison's line	1.6	5.8	9.4

The weather Bc Book 103 page 155

In the afternoon Carmen circuit again tested 2850 / 1425 / 1.65 Ohms P.M

Dry day

P.M 2900 to ground
The Kenite wire leading
to the lamp-posts lying
up and left in the air
to dry.

Monday — Yesterday
was a dry hot day
Nearly all the kenite
wires leading to the
Lamp posts have been
exposed to the air so
that they have no
connection with the
ground

July 19

8-30 a.m.

12820

14.10

6 3

7.7 Ohms to ground

a bucket of tar tried and its resistance found to be extremely high could not easily measure

Line 12 M

1265.0

132.5

6.3

695 Ohms

Insulation, Carmaux Circuit, July 19/18

All Kenite camp wires, where exposed to earth, are being overlaid with rubber tape (piping) and served with coal tar, then sprinkled with fine sand to harden.

July 19 2 P.M.

2900
14.5
6.3
8.2 Ohms

These lines cut off that were tacked to the boards and the resistance to the ground

3900

or 13.2 Ohms

other line 4200 Ohms

14.7

15900 Ohms between lines

29.5

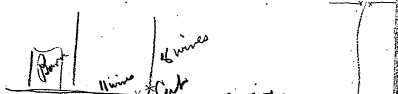
12.6

16.9 Ohms between the lines

about 2500 feet of the circuit left.

62.90
20.00
82.90
41.45
6.3
35.15 ohms To ground
36.65 —

* The lines cut at the corner



after rain

3800
19.3
12.70hms

July 20
J. St RR.

Insulation both wires leading to track to ground.

6290
25160
6256
6250
12000
7000
56660
282.3 Ohms to ground

Leading wires
1800
9.0 Ohms
2800
14.00
9
5. Ohms between tracks

R. R

1850
925
4.5
575

1200
600
45
1.5 Hours both sides to ground

21,296

21,296
20
425,920

42.

32280 — 4.5220
70 — 1.84151
6340 — 6.2007
2.5678

370 Ohms

B & R

The track disconnected just beyond the ~~fence~~ part which has been insulated

2 1
0 0 0 Ground

On 2 to ground

70 — 6250
6340 — 6250
6290
6290
8260
32280

41280	4.6158
70	1.8457
Comp 1500	6.8239
	3.2848

1920

1630	3.2122
70	1.8457
1500	6.8239
	1.8811

76.1

6250
11
73

R. R

No. 1 to ground

70
1500

6250
6250
6250
6250
6290
6290
2700
41280

Patient No 1

70
1500

1630 Ohms

1
200

6290
6290
1930
14510

72.5

R. R. ties

No 2 to tarred paper

1 / 200	6290
	780
	7070
	35.35
70 / 3200	6520

Results

* Paper 75 Ohms

Tar 38 Ohms

Three ties with no paper

R. R.

6290
9600
15.8.90.

79.

Cars off track

6290
6290
8250
6000
24830

124.15 Plus to ground from paper side.

R. R

San ride

6290
6290
6250
3400

224.30

112. Ohms

100 feet 50 Ohms

6290
6290
4580

170 80

85.14 Ohm

112
85.14

26.86

R. R. Between rails — Beeswaxing all night

13450 / 17.25 = 9 / 8.25 Ohms — 5 Volts.

Position

Cleaned 2 hours ago — sooty

Mount —

Removed Current to Negative

R. Same.

20 Watts =

Res —

26 Watts

Res — 1/10 [illegible] R.

July 22 1880

Everything very wet

July 22 1880

18 wire circuit

Between wires

6920
2100
9020

45.1
12.8
Ohms
32.8 = 32.5 Ohms

One side to ground

6290
31.45
+6.3
25.15 ohms

Other side

4400
22
6.3
15.7 ohms

July 22 1880

Line 6 miles laid in
Tuned boxes to Cedar Street.
To Ground

6700	7600
28.5	38
6.3	6.3
22.2	31.7

6290	6290
6600	6102
12890	12392
64.	61.96
12.6	1
51.4	

July 22. 1850.

Common circuit 25 wires

Between wires

6250
7150
13400

67.
12.6
54.4

To ground

6290
7000
13290
66.45
6.3
60.15

6290
6100
12390
61.9
6.3
55.6

R, R, July 22, 80

6000
6300
1700

Between tanks) 13 Volts

6290
6290
700
13280
91
42

6290
6290
1300
13880
9
4.8 Ohms

33 Volts the 0 ohms

31.1

6250
2
12500
6290
6290
5080
30.080

Balanced

R. R. between tracks

July 23 1880
rained nearly all night
no sun.

6290
6290
500
13080
13,000 Ohms
9.0
4.0 Ohms
4. Ohms between tracks

One side to ground

6290
1200
7490
4.5
2.99 Ohms

It is proposed to insulate one side only of the conductors and to leave the other uncovered. Test insulation one side only

R. R. July 24 9.00 A.M. 45

Resistance between the lines 2700/2

13.5

9

4.5 ohms between the tracks. Yesterday and last night were without rain and though the sun has not shown enough to dry the sleepers, I could not find any ground con and sidetr-

Cirrcuus circuit

6290
6280 boxes of ground
6256
6290 One side
6290
1400

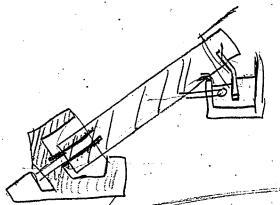
32720 (1)

163 Ohms

6250
6250
6290
6280 side
1400

20080 (2)

130.4 Ohms



A wire wrapped about one of the conductors and buried about six inches in moist earth

(2)

6290
6290
6250
9400
24236
121.

(1)

6290
6290
9400
21980
1094 Ohms

Canvas line
dry dry Jerk covered
with cloth and tired

6250
6290
6290
7760
26530 Ohms.

1.8549
1.8549
1.6464
8.0610
3.4172
26.20

4.1.5.5
3.4172
1.1.0.1.2

12.5 per A. P.

1324

Bank in oil

Capital

6250
6250
6290
6290
2nd to

27080

1354. Thurs Cold.

16 candles

6290
6290
4500

17380

86.9

2.5 = 1

71.6

1.9206
1.9206
1.6467
8.0588
3.5764
4.5185
.9421

3760

8.75 hr H.P.

1324
Burst in air short time Copied

3-2 46 candles

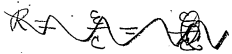
6290
6290
3720
16300
8 1.5

250 = D

83.3 Volts

$$\mathcal{E} = \frac{\mathcal{E}}{R}$$

$$C' = \frac{\mathcal{E}}{R+r}$$



$$RA = \frac{\mathcal{E}}{C}$$

$$\mathcal{E} = CR$$

$$C' = \frac{CR}{R+r} \qquad R = \frac{rC'}{C-C'}$$

$$(R+r)C' = CR \qquad R = 2r$$

$$RC' - RC = -rC' \qquad re \; C$$

$$RC - RC' = rC'$$

Galva on 25.8 Ohms in shunt 20 cells

285 275 560 — 560 552 1112 — 270 282 552 — 284 269

5000 Ohms in with galva

112 122 234 — 234 241 475 — 126 115 241 — 112

2000 Ohms with galva

187 173 360 — 360 365 725 — 175 190 365

r = 5000

C = 1112

C' = 475

C - C' = 637

$$R = \frac{r\,C'}{C - C'}$$

6.7451
2.8041
3.9410

5730 Ohms

$$R = \frac{6.3756}{2.8041}$$
3.5715

3730

N ? 2
5000
5560 ohms

475
5000
2378000

r = 2000

c = 1112

c' = 725

c - c' = 387

~~2.27 4000~~ ~~6.3472~~

2.5877

~~3.7595~~

~~5750 Ohms~~

725

~~2000~~

~~1450000~~ 6.1614

2.5877

3.5737

3740 Ohms

3730 Ohms

Resistance high resistance galva 3735 Ohms

~~One cell through~~

20 cells on railroad
20 feet long
~~19~~ 20 sleepers laid on
wet ground

~~Hot~~ sun all day

3 P.M. July 29, 1880

Resistance
8.900 Ohms 20 cells
of battery.

The weeds pulled from under
the rail which touched it
and the resistance
8.950 Ohms

13 spikes out
resistance
12.300 Ohms

The sleepers were allowed
to drop in some places

Ran up to 75000 — 100000 Ohms

blocked each end so
that rail rested on
Two sleepers

290,000 Ohms
standing on rails two men
220,000

25

.16

Three sleepers

250,000 Ohms

5280
4
2111 rails per mile
19 sleepers per rail
19999
2111
40009 sleepers per mile

4 | 400000
100 Ohms per mile

Both sides raised resting on two sleepers

Result There is no certainty in testing on dry rails and sleepers. Method make as good insulation as is needed to be tested then wet every thing and test.

1,600,000 Ohms
from rail on sleeper to good ground

Wet rail laying on the grass to ground
450 Ohms

Rail wet on 2 sleepers to rail on grass
240,000
After some minutes
78,000

July 29

Carmichs line

Wound all the length but about 300 ft on each cable and nearly all tarred

750 Ohms

July 31 1880 8-30 A.M.

Carmen's line all wound with cloth and nearly all tarred.

1400 Ohms

to ground each side

~~4000~~ Ohms

4000

July 31, 1880. 8-30 A.M. 73

Tin wire circuit. Boxes with exception of crossings exposed to the air.

R = 150 Ohm

Aug. 2, 1880. A.M.

Common circuit between the wires 3400 Ohms

9.4 Ohms in box placed at end of wires leading from box.

Line and wire

~~22.8 Ohms~~

22.8 Ohms

Line alone 13.3

Ground 9.5

22.8
13.3
9.5 Ohms

Cannon circuit
again 3000 Ohms between
the wires

about 3000 Ohms to ground
but continually altering as
the wire was moved by
those working on it.

Aug 3 P.M.
After heavy rain for
one hour and a half

1430 Ohms
About 700 Ohms per mile
Morning 900
To ground 700 - 700

20 | 5280
264 rails to mile

4250 / 264 = 3.6284
2.4216
1.2068

16 Ohms per mile

3 1/5 Ohms for five miles

Tarred paper under the rails dry 120,000 Ohms

4:30	[illegible]	7,000 Ohms
	"	6.200

Later in the afternoon ~~it~~ continually rising

Aug 3 after heavy rain for an hour
4250 Ohms

Aug 4 Rain during night very wet
2800 Ohms

Aug. 18 10. A.M.
25 cable + 18 cable.
3,010 ohms bet. wires
1200. & 1650. ground

12 feet rubber cloth 2" wide
weighs 790 grains

7000 grains make 1 lbs

.79 | 700 | .88
632
680

8.8
12
176
88
105.6 feet per lb

50 cts. per lb. estimated cost

That is about
1/2 ct per foot

Clear Rubber Tape wound on spindle
$\frac{21}{32}$ in. in diameter, 1 ft. long as wound
as to be double thick the entire length
When unwound tape weighed 160.2.9
" " measured 56.25. inch

437.5 / 160.2000 (34 grains oz. per. foot
141.25 of cable. $\frac{21}{32}$ in. dia.
18.950
18.500
.450.

100. ft. of same cable would take 34. g. or
2. lb. 2. g. which @ 60.¢ per. lb. = $1.28.¢

Marline wound on spindle same as on cable 2.5" in to each turn
7. turns to in. of cable
17.5
12. in to foot
210.0 inches of marline
on each foot of cable same size.

Marline measured and found to measure 231.5 inches.
Marline found to weigh 64?.4. grains per. foot on cable $\frac{21}{32}$ in. in diameter.
Marline costs 13.4 ¢. per. lb. add postage and 16. ¢. add freight.
To each foot add ½ ¢. for. winding on cable.

Aug. 23 1880.

Carmen's Circuit, 25. 18. 11. and Turnpike sections in, all others out.

Between wires 15. ohms
Ground 37. ohms both sides.

Aug 30 1880

25. 18 Turnpike Section.
between wires 42.9, Grounds
22.9 + 27.9 after the rain which
which was yesterday & today,
Aug 31 1880
Tried Cable 5000 Sam 3 lamps
Rubber 275 — 2 lamps rubber

5000
1000

Def

September 1, 1870

Tests on the wire in the Cannelle.

(1)

No 1
Def. 156 Res 84. ohms

(2)

~~Def~~ 215 = 120 ohms

(3)

Res 4850 ohms. Tare 8 Layers

Res 54 ohms Layers (4) Paraffine

$$\frac{100x}{100+x} = 100$$

1st new - 250 - 252½. — 502½

2nd set - 251 - 254. — 505

3rd set - 220 - 223. — 443 — new — 250 / 253 = 503

4th set - 252 - 254½ — 506½

5th set - 252½ - 254 — 505½

Aug 20 1880

Line tests (25 cable) 10

Left hand binding post tests with ground 682 ohms.

Right hand one 650. . .

Found across on one of the Camp posts (a dead cross) tested after 1hrs 2145 ohms.

Ground 1085 both

Lines as the 25 and 18 were

Section of Canmore circuit wrapped once with muslin band, wound with marline covered with ~~sand~~ cord, tar boiled with crude crate 12½ Half + Half

5.

Aug 21 1880

Canmore Circuit.

25. 18. + 11. wire sections in ckt.

765. ohms.

Aug 25, after Rain Thunder-storm & yesterday ground is wire cooked.

Canmore Ckt. 25.+.18. wire sections in ckt.

Ret. wire 3,700 ohms

Ground. 1,250. + 1,185 ohms.

Canmore Ckt. 25. 18. 11. + Turnpike sections in ckt.

Ret. wire 73.6. ohms (Aug. 26, 1880)

Ground 37.7 + 37.5.

Canmore Ckt. 25. 18. + 11. wire sections in ckt.

Ret. wire 38. ohms.

Ground. 200. + 22.

Aug 26. 1880.

$R = a$ — $C = \frac{1}{R}$ 1st line

$R' = b$ $C' = \frac{1}{R'}$ 1st & 2nd line

$R'' = \infty$ $C'' = \frac{1}{R''}$ 2nd line

$C' = C + C''$

Aug 27

Turnpike Road. 76 ohms

98

99

Dec 23. 1875

Edison Tp. Middlesex Co. Turnpike

all wire lines on the yacht shot one wire line by Edison Tp. on Turnpike.

Batt. gave 235. ohms.

Ground 131. & 83. ohms.

Dec 28. 1875.

Edison Ofst. to Ely on cross opp. office.

Batt. gave 130 ohms.

Aug 31 1880

Tested the wire covered by Howells with rubber cloth & tar. It was put in water. tested 120 ohms when plate was lowered down it went down to 77 ohms.

Bare wire tested also gave a Res of 100 ohms.

2.5 18 & Lamparkes. 440 ohm
Ground 25 + 24

25 + 18 + 11.
Ground 675 + 65
Res of Line 126.

18.25 wires

Line R. 950 ohms
Ground 497 + 452

Edison line to box on Railroad 76 ohm. Ground 43. 82

Edison's line to box on corner of the office 247 ohms.
Ground 76 + 172

Sept 2 1880

Cable No 4 3 thicknesses muslin each tarred with boiled coal coal tar. Res 120

Cable with three layers of Rubber cloth and 3 layers of tar. 320 ohms

September 3 1880

one length of 100 of Bare in wire
Submerged in water

Res 127 ohms

Cable No 1

One thickness Rubber tap (white) spirals overlapping about one third and tarred with stiff coal tar

Res 54 ohms. Current so low the vice plate was lower down than the other

Cable No 2

Three layers of Rubber cloth
3 layers of tar

amp	No
31	5000
1	4850
2	3200
4	2680
6	1500
8	2400
13	1910
14	2000
15	2000
16	1500
20	1039
21	1000

(No 3) Two Thickness of White Rubber cloth wound in opposite directions
Res 77 ohms

(4) 3 Thickness of cloth Parrced with boiled Coal Tar
Res 120 ohms.

No 5 Two Thickness of Cloth each covered with hot linseed oil.

Res Sept	Res
5	470
4	140
6	110

(No) 6 Cloth on Cable, with parrafin Rubber cloth (per) cloth again with parrafin.

Sep	ohms
5	1200
4	111
6	120

(7) 3 Thickness cloth covered with coal tar treated with gumtheine.

Sept 4 120 ohms

(8) Bare wire rubbed with dry hard paraffin Thin rubber cloth black ~~was~~ Covered with ~~a~~ black Rubber cement, Thin rubber cloth, Thin cement, Thin Rubber cloth smoothed down with hard paper

Sept 4 12500 ~~7000~~ Then went down to Sept 21 210

Sept 6 130

Sept 9 210

Sept 21 210

9 Bare wire rubbed with Paraffin Rubber cloth then Cotch and hot Paraffin then rubber and Paraffin and rubber cloth with more Paraffin

Dept 4 9000 went down in amount an hour after heard to 8500

Dept 6 120 ohms
21 120 " "

10 Rubber cement on bare wire Rubber cloth, muslin, Compound 3 # Rubber cloth, rubber cement, Rubber cloth rubber cement, Painted with chalk

Dept 7 2 9900
8 1400
9 500
10 450
21 150

11 Rubber Cement on bare wire Thick 115
" cloth
Muslin
Compound 1
Rubber cloth
" cement
Cloth
Cement
Duplicate with precipitated chalk
Sept 7 79000 Ohms
21 170 Ohms

12 Muslin on bare wire
Compound 2 ℔
muslin soaked in burned oil
Compound 2 ℔ Thinned cotton =
seed oil.
Muslin
Rubber cloth
" cement
" cloth
Sept 7 26 000
Sept 8 8 000
" 9 740
" 10 540
" 13 200
" 21 180

13 wire covered with marline
Then boiled in Compound
3 Then rubber cloth

14 7 (seven) strands wound
with marline

~~25 conductors has 25 ohms~~

Feb 25 Cable tests 550 ohms
" 18 Cable used 17 ohms,
There must be a dead
cross.

" 17 Cable 200 ohms.

25 wire cable + Carmichael Core
about 25 ohms.

15 Muslin
Refuse Compound
Muslin
Refuse Compound
Rept 13 Res 14 Ohms

16 White Rubber Cloth 3 Capers
Boiled Pine 1 hr 2 Servings
Made to Compare with
#9

Sept 13
176.000
14 85.000
15 30.000
16 12.500
21 1050

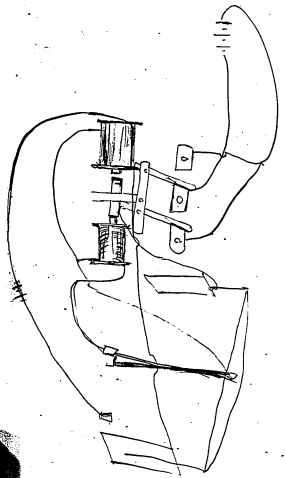
Test on Cable No 19

17 muslin, compound 4
muslin compound 4
muslin Boiled 4 hrs

Sept 17 70 ohms

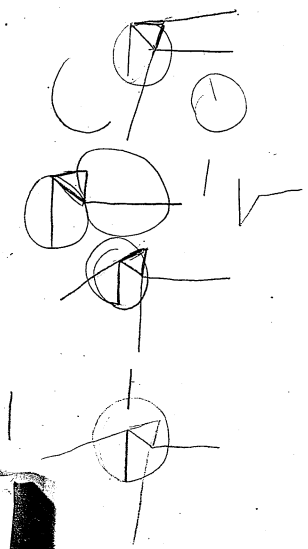
18 Three Thicknesses of muslin
soaked in hot Pine
tar.

Sept 18 — 870 ohms.
" 21 70 ohms



17 Rubber cloth compn 121
7 Rubber cloth compn
Rubber cloth.

S/17 1.117.000 ohms.
S/320 112200 ohms
" 21 70800 ohms



20 Muscle
Compound #7
Muscle
Compound 7
Muscle

Sept 21 37° ohms

21 Muscle
Muscle soaked in Compound #7
160

Edisons Line. 1.st section.

Oct. 14.th 1880.

Between wires 21,000. ohms.

Edisons Line. 1.st & 2.d section

Bet. wires 41,250. ohms.

Nov. 1. 1880.

Edisons ckt. to box on R. R. 560. ohms. to Davis 400. ohms. to end opp. lamp pety. 160. ohms to end back of Edisons Barn 260. ohms.

Nov. 2.d. 1880.

Carmens ckt. from Dynamo room to Wm. & Thos. Carmens House direct (side lines & cutout) 675 ohms.

Same ckt. with only turnpike line in. 240. ohms.

Same ckt. from dynamo room to box at corner of boardwalk & 800. ohms.

196 ohms – 22.1 for galvanometer
time to KK and branch line
communication test –
17.9 for direct time
196

Tests of insulations of wires on page 129
Made. Oct. Nov. & Dec. 1880. after two days working
Wire, and after dripping.

Test of insulation of wire from dynamo room to
Telegraph office 3rd line from dynamo room to
Telegraph office 325
367. Rheostat line and direct line
199.5 by Mabee

From dynamo room to corner 5th street
3rd line in front of Nat. 997
995 Mile line ~~Back~~ of Nassau st.
~~test~~ ~~wire~~ ~~a~~ ~~mile~~ ~~end~~

From dynamo room to box at
Brinckles, 1/6. ohms.
From dynamo room to box at cor.
of board walk this side of Asbury
House, 500 ohms.
From dynamo room to Tho. Germans
House, side line out, 490. ohms.
Same, side line in. 494. "

130 Galvanometer line 20. ohms

Dec. 2d 1880.

131

Insulation of lines.

Edison's circuit

First section, from dynamo-room to cor. opp. office. High

2d section, back of Dean's house 1145. ohms.

3d section, to cor. opp. Kinnicutt house, 283. ohms

4th section back of Kinnicutt house 280 ohms

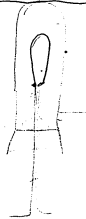
5th section back of Edison barn 208.

6th section, to turnpike 283. ohms

Dec 2d Insulation.
Edison Circuit

7th Section. to Davis hotel.
245. ohms.

8th Section. to Lamb factory
245. ohms.



Dec. Insulation.

Carmans Circuit.

1st section, to box opp. cor. of board walk.

2d section, to M. Carmens house.
Side line out.
N. line 1st l. in.
N. line 2d l. in
S. line in.

3d section, to D. Carmans house.
Side line out
" " in,

4th section, to box opp. Apthorp corner

5th section to turnbridge dep. M - Carmens House.
Depot line,
Davies' line.

Dec. Insulation of lines

R. R, or 6. wire, circuit.

1st section, to 4th or Cedar St.
Side line out.
" " in,

2d. section, S. on Cedar St,

3d. section, N. on Cedar. St,

Dec. Insulation of lines

Back circuit, (10 wire)

1st section, direct to first box.

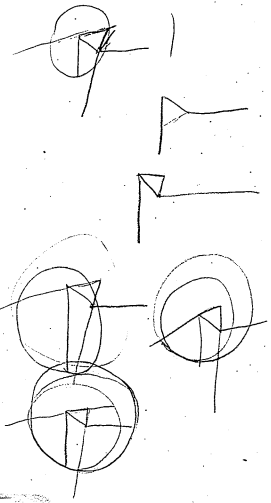
2d section, E. to Cedar St. with side line always in,

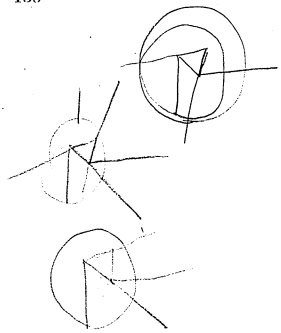
3d section N. to Parmins with side line always in,

4th section, to 3d box.

5th section to Cedar St. E.

6th section N. through Cooper's.





$c(X+r+g) = c'(R''+r+g)$

$cx+cr+cg \quad X = \frac{c'R''+c'r+c'g-(cr+cg)}{c}$

$cx \quad cr+cg$

$\frac{\begin{matrix}5&3\\0&0\\5&0\end{matrix}}{3} \cdot 10\,(5+10 \quad 20)\,\ldots$

35

$cx = cr+cg = \frac{c'R''+c'r+c'g}{c}$

C

30 ~~10~~ ~~15~~

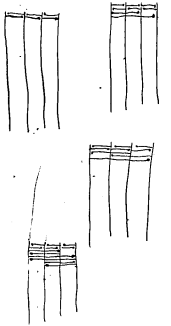
20 ~~5~~ ~~5~~

1- ~~20~~ 125+25

30

5

1



30
50
50
40
190

W. E. Box

Generator 40 ohms
Bell 85 ohms

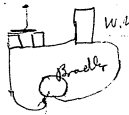
6290
2100
8390

500

~~2600~~
3000
2600
2100
1200
900
600
200
100
Rings

wood
250
150
100
70
40
30
20

Bergmans box



Generator 520 ohms
Bell 270

Bradley

W. E.

12500
1500
1350
250
150
100
90
50
Dash pots

Bergmans generator on W. E. hills

15,700 Ohms

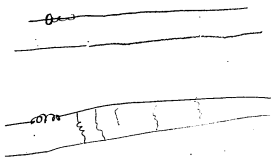
500	3400
	2600 again
250	1800
150	~~1700~~ ~~1200~~ bells nearer
	1500
100	1200
70	800
50	500
30	200
~~20~~	100
~~12~~	Rings

W. E. on Bergmans hill

7000 Ohms

500	3800
	2000
250	
	1300
150	
100	1400
	500
70	
50	100
25	Rings

Aug 13 '80 \ 41-41
Aug 14-'80 \ 39½-39½

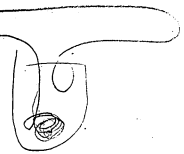


205 — 16 candles.
2[illegible] — 2

276-
282 Aug 14-80.

torn out 1 page

X 1

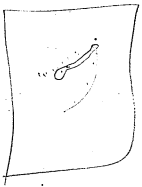


40 1/2

40 1/2

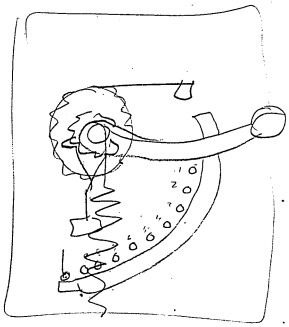
40

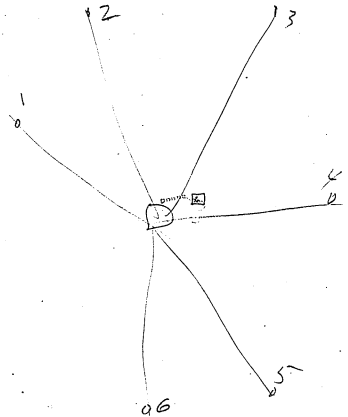
89½
89½



40 (12½)
20
60
MAF
440
60
64.80

4.




2
3
1
4
5
6

$$\varepsilon R + \varepsilon r + \varepsilon q = \varepsilon'(r + r + q)$$

$$R = \frac{\varepsilon' r + \varepsilon' r + \varepsilon' q - \varepsilon r - \varepsilon q}{\varepsilon}.$$

$$\varepsilon R = \varepsilon' r + \varepsilon' r + \varepsilon' q - \varepsilon r - \varepsilon q$$

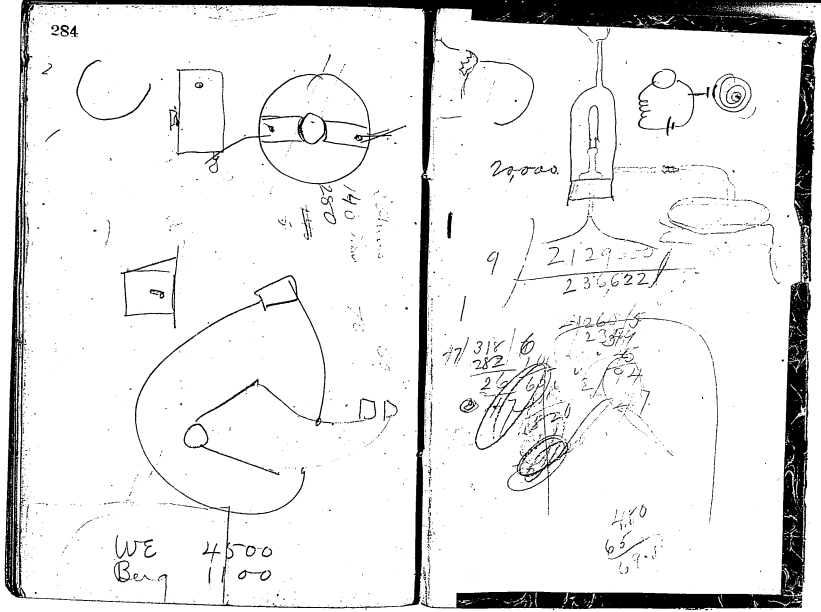
$$+\varepsilon' q + \varepsilon q = \varepsilon R + \varepsilon' r + \varepsilon r + \varepsilon q$$

$$\varepsilon' q + \varepsilon = \varepsilon R + \varepsilon' r + \varepsilon r + \varepsilon q$$

$$\varepsilon' q = \varepsilon R + \varepsilon' r + \varepsilon r + \varepsilon q - \varepsilon$$

$$\varepsilon' = \frac{\varepsilon R + \varepsilon' r + \varepsilon r + \varepsilon q - \varepsilon}{q}$$

$$\frac{\varepsilon}{2} = \frac{3}{\varepsilon}$$


WE 45 00
Berg 11 00